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# International Stock Market Leadership and its Determinants

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## Abstract

We study time-varying price leadership between international stock markets using a Markov switching causality model. We demonstrate variations in the causality pattern over time, with the US being the dominant country in causing other markets. We examine the factors which determine a country's role in the causal relationship. For country-specific factors, we show that trades openness increases price leadership. We also find that the lead–lag relationship between the stock markets is weaker during crisis periods, confirming the “wake-up call” hypothesis, with markets and investors focusing substantially more on idiosyncratic, country-specific characteristics during the crisis.

Key words: Causality, price leadership, financial crisis, causality factors

GEL classification: G12, G10,

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## I. Introduction

Understanding the interconnectedness of world financial markets is important to regulators and practitioners. Emerging markets have been seen to lead several financial crises affecting the global market before the 21<sup>st</sup> century. These include examples such as the “Tequila effect” of 1994, the “Asian flu” of 1997 and the “Russian cold” of 1998. However, the more recent crises arose from the developed economies; these events known as the “Subprime” and “Eurozone sovereign debt” crises. As a result there is great interest in the underlying fundamentals of how developed and emerging stock markets are connected with one another. The aim of this study is to extend our understanding of international stock market co-movement in a number of ways. In particular, we examine how international stock markets interact over time. Where do the shocks originate? Which countries are more vulnerable to external shock? What factors affect a country’s price leadership and vulnerability to external shocks?

We address these research questions with a new research approach that has two distinct advantages. First, previous studies often use correlation as the main measure for capturing co-movement. However, this method does not capture the directional effect of the return spillover. We capture this directional impact through a causality framework. Second, most studies consider the time-varying and conditional relationship by examining sub-period correlation where the sub-periods are exogenously identified by, for example, significant market events (e.g., Forbes and Rigobon, 2002; Chiang et al., 2007; Corsetti et al., 2005). These approaches limit researchers’ ability to fully describe the dynamic of the interconnectedness. We extend this facet of the literature by capturing time-varying causality in a Markov switching analysis. This framework of analysis enables us to further explore what determines price leadership in the global context.

Empirically, we investigate causality among 10 major stock exchanges, including both highly developed markets (US, Japan, UK, France and Germany) and emerging ones (Brazil, Russia, India, China and South Africa), using a Markov switching model. With available data in the period between 1974 and 2012, we find that the 90 country pairs are in the causality regime for, on average,

16% of the sample period. We further document that the US market plays the most important role in affecting other markets, spending on average 34% of the time in the (leading) causality regime. Germany and France are in second and third place, with 30% and 28% of the sample period spent in this role. The emerging markets China, Russia and South Africa are in the middle of the ranking, while Japan, the UK, India and Brazil are at the bottom. We uncover evidence of regional segmentation (due to geographical and time zone proximity) and development segmentation (between the emerging and developed counties).

We also explore potential differences in the pattern of causality during periods<sup>1</sup> of global crisis and identify two main findings. First, Germany has the strongest overall price leadership, overtaking the US; this reflects the importance of Germany's role in price discovery during the eurozone crisis. Second, the US overtakes China to become the country that is third most affected by the movements in other markets; this suggests that during global crisis periods the US becomes a hub of global shocks, both initiating and receiving them.

To study the determinants of price leadership, we run a panel regression analysis using pair-month observations. The dependent variable is the probability of one country (leading) causing another country (lagging) during the focal month. In total, there are 24,582 pair-month observations for the 90 directional pairs.

For determinants, we consider a list of variables including global and country-specific factors: global market conditions, comprising world market volatility (Longin and Solnik, 1995; Carrieri et al., 2007), gold and oil price volatility (Chen et al., 1986; Tufano, 1998) and a financial crisis period indicator (Mishkin and White, 2003); country stock market conditions, comprising market development (Carrieri et al., 2007), dividend yield differential (Longin and Solnik, 1995), price-earnings ratio (Bekaert et al., 2007), stock market volatility (Corsetti et al., 2005; Wälti, 2011) and market turnover (Christoffersen, 2012); and country economic conditions, comprising inflation

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<sup>1</sup> We include five crisis periods including the 1987, 1990, 1997 and 2000 crises identified by Mishkin and White (2003), and the recent financial crisis between 2007 and 2010.

(Boyd et al., 2001), interest rates, currency reserves (Aizenman and Lee, 2007), trade openness (Chinn and Forbes, 2004) and bilateral exchange rate volatility.

We find that global market conditions are important determinants of connectedness. When there is higher volatility in the global stock market index, there is a higher level of causality between countries. Interestingly, we find that the lead–lag relationship between stock markets is weaker during crisis periods. Consistent with Bekaert et al. (2013) we reject the globalization hypothesis that links transmission of the crisis to the extent of global exposure. This finding confirms the “wake-up call” hypothesis proposed by Goldstein (1998) and Masson (1999), with markets and investors focusing substantially more on idiosyncratic, country-specific characteristics during the crisis.

For country-specific factors affecting price leadership, we find that the higher the dividend yield, the greater the trade openness and the stronger the market sentiment (measured by price–earnings ratio), the more likely it is that the country’s stock market movement would have influence on other markets. Conversely, we find that lower trading volumes (measured by market turnover) and less trade openness increase the probability of a country’s stock market being influenced by other markets. These findings suggest that markets with a stronger cash-flow position and more mature companies (companies paying out higher dividends) are more likely to lead the rest of the global market. They also demonstrate spillover in market sentiment; stronger market sentiment being more likely to spread to other markets. Trade openness is an important condition for interconnectedness, suggesting a strong linkage in the goods and financial market. Finally, a thinner market is more likely to be influenced by other markets.

We conducted a Wald test on the difference in the country dummy dividing the developed and emerging markets, which shows strong evidence that emerging countries are more likely to be caused and developed markets are more likely to cause others. It is indicative of the information advantage and investor sophistication in developed countries.

This paper contributes to the literature of international market co-movement in two main ways. First, it proposes and applies a nonlinear Markov switching model for capturing the direction of causality between markets. Modeling the co-movement of stock market returns is a challenging task. The conventional measure of market interdependence, starting from the symmetric, linear dependence metric of the Pearson correlation coefficient, is suitable for measuring dependence in multivariate normal distributions. It represents merely an average of deviations from the mean without making any distinction between large and small returns, or between negative and positive returns (Poon et al., 2004). However, the nonlinear models (such as the generalized autoregressive conditional heteroskedasticity (GARCH) model) that were later developed to measure co-movement (see Dungey et al., 2005; Cappiello et al., 2006; Aloui et al., 2011, Celik, 2012), while addressing some of the above shortcomings, still fail to capture the direction of co-movement and contagion<sup>2</sup>. As Bekaert and Harvey (1995) point out, one of the advantages of using conditional Markov switching models is to describe expected returns in countries that are segmented from world capital markets in one part of the sample and become integrated later in the sample. Our post-estimation analysis framework provides an illustration of how the pattern of causality can be measured and visualized for whole and sub-period analysis. It can be adopted to study the impact of global or local events on the return spillover among markets.

Our second contribution lies in examining the determinants of price leadership between countries. Despite a large body of literature on international market interdependence, the existing empirical evidence remains ambiguous regarding the nature of the dynamic interdependence among and between developed and emerging markets. Our empirical findings suggest a strong developed–emerging divide, which has important implications for international portfolio management. We provide complementary evidence to that of Christoffersen et al. (2012), who show that on average, for a developed market, dependence on other developed markets is higher

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<sup>2</sup> The GARCH family of models also has the advantage of modeling the volatility persistence that our method cannot directly address (Lamoureux and Lastrapes 1990).

than the average interdependence of emerging markets. They divide the sample countries into developed and emerging categories but they are silent about the leader–follower relationship. Moreover, some market-segmented studies considering either developed or emerging country samples, or both on a limited scale (see, e.g., Carrieri et al., 2007; Wälti, 2011; Christoffersen, 2012), find certain factors significant in the integration of co-movement. But to the best of our knowledge, this is the first study that identifies the factors affecting whether a country leads or follows. It is important to make the distinction between causing and being caused when the focus is to identify the source of shocks and the behavior around absorbing external shocks.

The rest of the paper is organized as follows. Section II provides a literature review. Section III presents the estimation methodology and summarizes the price leadership results. Section IV presents our analyses of the determinants of price leadership. Section V concludes the paper.

## **II. Literature Review**

### **A. International Stock Market Causality and Price Leadership**

There is a large volume of research in the area of stock market co-movement and contagion. Previous studies of cross-market transmission of shocks based on different methods find mixed evidence. Most of the evidence is drawn on the contemporary relationship among markets using correlation analysis. However, there are some exceptions. For example, early evidence by Eun and Shim (1989) show that return innovations in the US affect major developed markets, but not vice versa. Given the increase in globalization in the past three decades and the fast developments in the emerging world, a more updated picture regarding the directional transmission of global shocks is warranted. Our first research question concerns where the global shock is generated from and which countries are more vulnerable to external shock.

The transmission mechanism of co-movement and contagion has been discussed theoretically by a number of authors (Masson, 1998; Kaminsky and Reinhart, 2000; Pericoli and Sbracia, 2003). Among them, Pericoli and Sbracia (2003) provide a theoretical framework to

highlight different channels for the international transmission of financial shocks. They show how crises that occur in one country can be transmitted across countries, so that whenever negative news develops in a given market, it will soon be learned by participants in other markets. Recently, Longstaff (2010) identifies three possible channels by which shocks in one market spill over into other markets. First is the information channel: the negative shocks in one market (e.g., the arrival of economic news) directly affect the cash flow or securities of other markets (Kiyotaki and Moore, 2002; Kaminsky et al., 2003). This might be due to risk aversion, wealth effect, panic, asymmetry of information and noises trading that transmit the information from more liquid or price-discovered markets to other markets. Second is the liquidity channel: the investors who suffer losses from one market may find their ability to obtain further funding impaired. This potentially creates a downward spiral in overall market liquidity and other asset prices via a “flight to quality” (Allen and Gale, 2000; Brunnermeier and Pedersen, 2009). In this process, speculators’ capital decreases, margins increase, liquidity reduces, volatility increases and correlation increases. This creates contagion shocks across all markets via different assets. Third is the risk premium channel: a severe negative shock in one market may be associated with an increase in risk premium in other markets via time-varying risk premiums (Vayanos, 2004; Acharya and Pedersen, 2005; Longstaff, 2008). By this mechanism, contagion occurs as negative returns in the distressed market affect subsequent returns in other markets.

Barberis et al. (2005) argue that market sentiment drives co-movement between stocks. Kodres and Pritsker (2002) suggest that portfolio rebalancing creates rational contagion, the severity of which depends on shared macro-risk factors and the information asymmetry in each market. Kyle and Xiong (2001) propose a wealth effect, where losses by arbitragers may lead to liquidations in several markets, thus inducing contagion.

Regarding the relationship between emerging and developed markets, recent studies demonstrate that emerging markets are more segmented compared to developed ones (e.g., Bekaert et al., 2011; Carrieri et al., 2007; Christoffersen et al., 2012) due to their fundamental characteristics



such as size, institutional and corporate structure, and geographic location. Doornik and Van Roye (2013) analyze the international transmission of financial stress over the sample period of 1970–2012 for 20 major economies. They show that the spillover of financial stress runs mainly from advanced to emerging economies and not in the opposite direction. However, there is evidence that emerging markets are playing an increasingly important role in the global market (see, for example, Wilson and Purushothaman, 2003).

## **B. Market Connectedness during Crisis Periods**

Bekaert et al. (2013) describe three possible transmission mechanisms for co-movement in equity markets. First, the globalization hypothesis: systemic contagion implies that contagion and co-movement during crises occur strongly in those economies that are highly integrated globally through, for example, trade and financial linkages. Such global contagion is transmitted through common shocks or push factors. Ahrend and Goujard (2014) examine the role of different forms of financial integration and find that bilateral trade and common bank lenders have a significant role in asset pricing during a crisis. Second, the “wake-up call” hypothesis: a crisis initially restricted to one market segment or country provides new information that may prompt crises across markets and borders (Goldstein, 1998; Masson, 1999; Goldstein et al., 2000). Under this hypothesis, domestic fundamentals are important. This is also termed domestic contagion as it arises from country-specific shocks. Macroeconomic factors that are not important in normal times suddenly matter in times of crisis (Fratzscher, 2009). Mobarek et al. (2016) use a dynamic conditional correlation mixed data sampling (DCC-MIDAS) approach to assess the validity of the wake-up call hypothesis during the global financial crisis. They examine the country-specific economic, financial and behavioral factors and find support for the wake-up call hypothesis. Finally, the pure contagion hypothesis suggests that a crisis induces herd behavior where investors stop discriminating across firms and countries based on economic fundamentals. It may induce global rather than domestic contagion through asset holding by international investors (see Boyer et al., 2006).

There is an ongoing debate in the literature about the existence of contagion from crisis episodes to date. There are mainly two schools of thoughts. One group supports the notion that crisis causes contagion (e.g., King and Wadhwani, 1990; Lee and Kim, 1993; Calvo and Reinhart, 1996) and another group does not (e.g., Forbes and Rigobon, 2002; Brière et al., 2012).

Overall, the above literature suggests that there is co-movement among global stock markets and that the relationships are time varying. However, it is essential to explore the direction of causality and the dynamic relationship between emerging and developed markets, including the recent crises. In this paper we readdress the issue, including five crisis episodes within a long time series, with a new method which is free from the above bias and also models the direction of co-movement and contagion.

### III. Data and Methodology

#### A. Data

We are interested in the price leadership among and between developed and emerging markets. To this end, we include well-known BRICS countries (Goldman Sachs Global Economics Group, 2007) as representative of emerging markets. Our final sample includes 10 stock markets: US, UK, France, Germany, Japan; and Brazil, China, India, South Africa, Russia. We collect available data on the country MSCI Indexes, denominated in dollars, from Datastream between 1974 and 2012.

#### B. Markov Switching Causality Model.

To estimate the time-varying causality relationship from one daily market index return  $R_{j,t}$  to another market index return  $R_{i,t}$ , we specify a Markov switching model as follows:

$$(1) \quad \begin{aligned} R_{i,t} &= \mu_{i,1} + \varphi_{i,1} R_{i,t-1} + \psi_i R_{j,t-1} + \varepsilon_{i,1,t} & \text{Regime 1} \\ R_{i,t} &= \mu_{i,2} + \varphi_{i,2} R_{i,t-1} + \varepsilon_{i,2,t} & \text{Regime 2} \end{aligned}$$

With a significantly positive  $\psi_i$ , Regime 1 indicates that  $R_{j,t}$  Granger-causes  $R_{i,t}$ , while Regime 2 indicates that  $R_{j,t}$  does not Granger-cause  $R_{i,t}$ .  $R_{i,t-1}$  has been included to control for

autocorrelation of  $R_{i,t}$ . This parsimonious setting in time-series dynamics provides the consistency among different pairs in our sample. Causality from one market to another can be interpreted as a contagion effect and it is a better measurement for contagion than co-movement or correlation as it also specifies the direction of contagion. The Markov switching setting allows the contagion effect to switch on and off dynamically<sup>3</sup>.

We chose a Markov switching (MS) model to account for potential structural change and the time-varying nature of causality between countries. This model has the following notable benefits. First, unlike previous literature dealing with structural change by sub-period analyses, Markov switching embeds the time-varying nature of causality in a stochastic process. Compared to other nonlinear models (e.g., threshold or smooth transition models), the MS model does not require specific, explicitly stated variables to determine regime shift. Second, it allows for regime change in multiple locations of a sample with probabilistic inference about the dates at which changes in causality occurred during the sample period. It also provides a clear classification of states for each observation in the sample. After estimation of the model, this allows us to explore the determinants of any regime changes. Estimation of the MS model produces a time series inference of causality regime which allows us to investigate the determinants of causality between countries.

Our definition of causality is contingent on the choice of measurement interval, as Comte and Renault (1996) suggest that notions of causality are defined for a given unit of time, which is generally dictated by the observation schedule. Granger (1988) points out the importance of recognizing this discreteness in the interpretation of causality results. Renault et al. (1998) criticize the potential drawback of using of discrete data to examine causality as it excludes the analysis of

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<sup>3</sup> There are limitations to this pairwise estimation approach. We thank the referee for raising this point. The reason for this choice over a multivariate causality analysis is one of practicality. The number of parameters grows significantly with the number of countries in the analysis. For example, in a bivariate MS causality model of Psaradakis et al. (2005), there are four states capturing the possible causality combination: A causing B, B causing A, A and B having two-way causality, and A and B having no causality. The number of states would quickly increase to 32 as each of the original states interacts with the causality states of A and C, and B and C. The number of possible combinations of pairwise causality states would be too large to feature in an estimation. We therefore resort to this pairwise approach to enable us to quantify the observed relationship between each pair of countries. We see common causes and missing variables as a challenge to our approach, and we aim to identify the drivers behind the observed causality captured by the model in our second stage of analysis.

events that might happen during a single period. Therefore causalities detected at finite horizons are known to be exposed to spurious effects (Comte and Renault, 1996; Renault et al., 1998) when the underlining data are from a continued-time process. In the current research context, the instantaneous causality effect is not of a great concern given that countries from different continents opened at different time period. We therefore chose close-to-close daily return intervals to study cross-country causality. While we acknowledge that such choice of observation schedule may potentially create spurious effect in our results for those markets that open simultaneously. Such choice is relevant economically given the important reference points closing prices provide, especially in relation to derivative contracts, index valuation and the unwinding of positions. One further benefit of daily data over intraday data is that it allows for examination of price dynamics over long-run horizons. Studies employing intra-day data typically use short-run horizons of less than one year.

### **C. Construction of Time Series Causality Variable**

To study the determinants of price leadership, we run a panel regression analysis using pair-month observations. The dependent variable is the probability of one country (leading) causing another country (lagging) during the focal month. Specifically, for each pair of countries we construct two time series variables that capture the state of causality in either direction. For example, in the US–China pair, to identify the extent of price leadership by China over the US in a given month, we sum the number of days that it is in the causal state (Regime 1 in Equation 1) in the regressions where China is on the left-hand side of the regression and the US in on the right-hand side, and divide this by the total number of days in that month. This produces the probability of China causing the US in that particular month; the probability of the US causing China is similarly constructed. In total, there are 24,582 pair-month observations for the 90 directional pairs. We present the explanatory variables in Section V.

## **IV. Time-Varying Price Leadership Estimation**

## A. Estimation Summary

We report the estimation summary in Table 1. Panel A shows the mean and median of estimated parameters across the 90 country pairs and also the number of parameters significantly different from 0. The last column shows the number of parameters which are not only significantly different from 0 but also in a direction indicating causality (positive coefficients). More importantly, there are 76 of 90 pairs with a significantly positive causality coefficient, which means causal relationships between two markets exist in most of our sample pairs.

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Insert Table 1 here

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Panel B shows the average transition matrix across the 90 country pairs, where the number in column  $i$  and row  $j$  represents the probability of switching from state  $i$  to state  $j$ . It shows that the conditional probability of switching to another causality regime is higher than that of staying in the same regime; thus switching between regimes is a not a rare phenomenon in our sample.

Panel C summarizes the ergodic probability of causality regimes across the 90 country pairs, showing the overall percentage of data points in the causality regime (State 1). The Leading columns show the mean and median ergodic probability of a given country being on the right-hand side of the equation (i.e., the country that *causes* the other). We sort the counties by their mean ergodic probability. This shows that the US is the country with the greatest causal impact on other countries; the average percentage for the US being in the regime to Granger-cause other countries is 34%. Germany and France are in second and third place, being in the causality regime 30% and 28% of the time respectively. China, Russia and South Africa are in the middle of the ranking, while Japan, the UK, India, and Brazil are at the bottom. On average across the 90 country pairs, they are in the causality regime for 16% of the sample period.

The Lagging columns show the mean and median ergodic probability of a given country being “on the left-hand side of the equation” (i.e., the country that *is caused by* the other). In this

case, Brazil is the country which is most often subject to external shocks; on nearly 40% of days Brazil's market movements are affected by the previous day's movements in other markets. Germany and Russia are the two countries that are most resilient to external shocks, with less than 3% of their sample days caused by other markets.

## B. Patterns of International Stock Market Leadership

We report the pattern of international stock market leadership pictorially using a chord diagram. Figure 1 shows the bilateral price leadership between countries. The connection paths between each country pair are colored according to the dominant country, with developed countries in red and emerging in gray. The bandwidth indicates the relative strength of the connection. For example, in the US–China pair, to identify price leadership we compare the ergodic probability of being in the causality regime, both where the US return is a function of China's return and vice versa. We find that China causes the US with a probability of 2.3% and the US causes China with a probability of 24%; since 24% is larger than 2.3%, the US is the dominant country in this relationship. Therefore, this connection is colored in red (the US being a developed country) with a wider width from the US and a narrower end at China.

Panel A shows the hierarchy of leadership (causing) while Panel B shows the hierarchy of lagging (being caused).

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Insert Figure 1 here

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First, there is a clear emerging–developed market divide. Most of the causality identified is within the two groups rather than between them. On average there is more activity originating from the developed markets than the emerging markets, suggesting that more of the global equity information will originate in developed markets. Second, the US has the largest influence overall among these countries. It has particularly strong influence in India, the UK and Japan, relatively small influence on China, and no identifiable influence on Brazil or South Africa. There are three

countries that have net influence on the US: France, Germany and Russia. Third, among the emerging markets China has the strongest influence on other countries. It has influence mainly on other emerging markets, including Brazil and India, with one important exception: France. Specifically, there is strong two-way causality between China and France. This highlights a strong tie between these two countries' economic activities which has not been recognized in the literature.

When the effect of lagging is examined, Panel B has the following notable results. First, Brazil is the most vulnerable to external shocks, as Table 1 also indicates; receiving shocks from both developed and emerging countries. This possibly reflects its resource-reliant economy, which has strong connections with economic activities in both emerging and developed markets. Second, India's market is mainly influenced by movement in developed rather than emerging markets. Third, the countries which mainly cause China's stock market movements are France, the US and the UK.

The causal relationship among the markets also shows a pattern of regional effect. There is more between-region than within-region causality. For example, there is very little causal relationship between the US and Brazil, being in the same continent and time zones. Similarly the UK, Germany, France and Russia, or Japan, China and India, have little lead-lag relationship. This finding suggests the importance of around-the-globe information flows. Stock markets in different continents discover, or react to, local and global information in parallel at the opening hours of their time zone, and this information is subsequently reflected in other time zones.

Overall, then, our analysis shows that developed markets have higher price leadership, and that price leadership is also partly a reflection of information flow among different geographical regions. This is consistent with the findings of Doornik and Van Roye, (2014).

We next examine causality during crisis periods, as shown in Figure 2. It shows that the pattern of interconnectedness is not always similar during crisis periods. The key difference is that Germany takes the place of the US as the dominant (leading) country. Moreover, when the receiver (lagging) end of the return spillover is studied, we find that during crisis periods, the US is more

vulnerable to external shock than in the normal period; it became the country third most affected by other countries' movements.

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Insert Figure 2 here

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## V. Determinants of Price Leadership

This section presents the analyses of the determinants of price leadership. The dependent variable is the monthly average of the causality-indicated variable for a given pair-month. It measures the percentage of days in a given month in which the focal country is causing the other country. We group the determinant variables into three categories covering global and country-specific factors: global market conditions, country stock market conditions and country economic conditions. Global market conditions comprise world market volatility (VOL\_W), oil price volatility (VOL\_oil), gold price volatility (VOL\_gold) and a financial crisis period indicator (CRISIS dummy). Country stock market conditions comprise market development (MD), dividend yield differential (DYD), price earnings ratio (PER), (country) stock market volatility (VOL\_C) and market turnover (TOV). Country economic conditions comprise inflation (IFL), interest rate (IR), currency reserves (CRC), trade openness (TOP) and bilateral exchange rate volatility (VOL\_FX). Appendix B presents a discussion of our choice of variables in the context of the literature. Among these variables, the precise definition and measurement of financial crisis is a difficult task, as pointed out by Mishkin and White (2003). Using the October 1929 and October 1987 crises as benchmarks, they suggest using a 20 percent drop in the market to define a stock market crash. We follow their definition and identify the crisis periods of 1987, 1990 and 2000, as identified in their paper; we also include the 1997 Asian financial crisis and the latest financial crisis between 2007 and 2010.

Table 2 presents a summary of the country-specific variables used in the regression analysis. N is the number of monthly data points available for a given country. In general, emerging markets



have lower levels of market development (MD), higher relative levels of currency reserves (CRC), higher stock market volatility (VOL\_C) and market turnover (TOV), and higher inflation (IFL) and interest rates (IR). This country-wise analysis of the explanatory variables shows that they are mostly but not entirely consistent within each group of countries (emerging or developed). This suggests that country-specific factors are also important.

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Insert Table 2 here

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We report the analyses on the determinants of price leadership in Table 3, showing Models 1 and 2 for the determinants of leading and lagging respectively. The dependent variable is the percentage of days in the causality regime in a given month. In Model 1 (2), we use the characteristics of the leading (lagging) country as explanatory variables. The regressions are estimated with year and country fixed effects to control for unobservable heterogeneity<sup>4</sup>.

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Insert Table 3 here

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Models 1 and 2 show that global uncertainty in the financial market (or VOL\_W) induces higher levels of spillover in market movements. This is consistent with previous literature arguing that world market volatility is an important determinant of correlations across national markets (Erb et al., 1994; Farrell, 1997; Longin and Solnik, 1995). We also find that higher oil price volatility (VOL\_oil) reduces the lead-lag effect among global stock markets. Interestingly, we find that the lead-lag relationship between stock markets is weaker during crisis periods. These results suggest less commonality during the crisis period; that is, most of the shocks emerge locally and only affect local markets. Consequently, similar to Bekaert et al. (2013), we reject the globalization hypothesis

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<sup>4</sup> To control for general heterogeneity we reports heterogeneity robust errors in the regression. We also estimate the regressions without country fixed effect and confirm that the main findings regarding financial crisis, market development and trade openness are robust with or without the country fixed effects.

that links the transmission of the crisis to the extent of global exposure. Instead, we confirm the old “wake-up call” hypothesis, with markets and investors focusing substantially more on idiosyncratic, country-specific characteristics during the crisis; this is also in line with the findings of Mobarek et al. (2016).

Among country-specific factors, two variables have clear directional effect on the leading and lagging of a country’s stock market price movement: market development (MD) and trade openness (TOP) enhance a market’s leadership role. In other words, these variables have opposite-sign effects in the leading and lagging determinant regressions.

In particular, after controlling for potential unobservable heterogeneity through country and year fixed effects, we find that market development inhibits a country’s stock market leading role. This finding contributes to the debate on the effect of market development on market movement correlation. Our evidence is consistent with Christoffersen (2012), who finds a negative but insignificant relationship between market development and the correlation between developed country pairs. Johnson and Soenen (2002) argue that it is difficult to predict the sign effect of market development on market connectedness, since rapid-growth economies may become independent and the co-movement pattern is time varying. Our findings suggest that market development does not lead to dominance in overall price discovery leadership in the global context; as we find in Model 2, market development makes a country more sensitive to external shock. Overall, this suggests that more developed markets are more connected to the outside world and therefore more sensitive to external factors. Less developed countries are more segmented from the global system and therefore less affected by external shocks.

We also document that trade openness (TOP) has two effects on a country’s stock market leadership, which is consistent with the findings of Bekaert and Harvey (1997, 2000), Forbes and Chinn (2004) and Ahrend and Goujard, (2014). First, a more open market is more likely to lead other markets; this suggests that trade connectivity is a channel for exporting domestic market shocks. Second, a more open market is less likely to be affected by external shocks. This finding

has important implications for a country's trade openness policy. One of the concerns regarding opening the market to the rest of the world is its potential side effect of greater vulnerability to external market shocks. We show that, as regards the stock market at least, greater trade openness makes the market more resilient to external shocks.

Baele and Soriano (2010) find that both dividend yield and PE ratio increase the financial integration of stock market co-movement. Consistent with their findings and those of Longin and Solnik (1995), we find that dividend yield differential (DYD) and price earnings ratio (PER) are positively related to causality in both directions. Price earnings ratio (PER) can be seen as a proxy for market sentiment (Bekaert et al., 2007). Our findings therefore suggest that there is spillover of market sentiment. Furthermore, bilateral exchange rate volatility (VOL\_FX) increases causality in both directions. Similarly to Bekaert and Wu (2000), Bae et al. (2003) and Christoffersen et al. (2012), we also find that countries with higher stock market volatility (VOL\_C) and lower market turnover (TOV) (i.e. thinner markets) are more likely to be affected by external shock.

Finally, the country dummies show a similar ranking to that observed in the ergodic probabilities in Table 1. We conducted a Wald test on the difference in the country dummies between the developed and emerging groups. It shows strong evidence that emerging countries are more likely to be caused and developed markets are more likely to cause others. It reflects the information advantage and investor sophistication in developed countries.

## **VI. Conclusion**

The rapid progress of globalization has attracted great attention from governments, regulators and academics. To this end, quantifying the cost and benefit of such progress to the domestic and global economy is important for decision makers. We contribute to the research on market connectedness by uncovering the lead-lag causality of a country's stock market returns. We show that developed markets dominate overall price leadership, with the US, Germany and France as the main leaders. China and Russia are the strongest leaders among the emerging countries. On the

receiving end, emerging markets are more vulnerable to external spillover; in particular, Brazil and India are most affected by other countries' movements.

More importantly, utilizing a state-dependent model, it allows us to examine the time-varying nature of these causal relationships and the underlying determining factors. Interestingly, we find that the lead–lag relationship between stock markets is weaker during crisis periods. Consistent with Bekaert et al. (2013), we reject the globalization hypothesis that links the transmission of the crisis to the extent of global exposure. Instead, we confirm the old “wake-up call” hypothesis, with markets and investors focusing substantially more on idiosyncratic, country-specific characteristics during the crisis. For country-specific factors, we find that market development inhibits price leadership while trade openness enhances a market's leadership. There is also evidence that high dividend yield, high market sentiment (for which PE ratio is a proxy) and high bilateral exchange rate volatility would enhance two-way causality.

Overall, we demonstrate that global market price leadership is time varying and can be captured by our proposed framework, which provides a tool to examine market connectedness. Such methodology would be a useful contribution to regulatory technology in detecting the origin of financial contagion which complements the existing approach of DCC-GARCH family models that cannot offer directional inference. Our determinants study finds that trade openness has a strong directional effect on price leadership, suggesting that levels of financial market connectedness are strongly influenced by trade connectedness. The practical implication of this finding is that to protect domestic market from financial market contagion, countries should consider diversification of their trade relationships to avoid significant impact coming from a single trading partner.

Ours is a pioneer study on time-varying causality, which successfully identifies the factors affecting whether a country leads or follows in the arena of international stock market leadership. Nevertheless, we acknowledge the limitations of using a pairwise causality approach: bivariate analysis makes it possible to estimate nonlinear causality for large number of pairs, but fails to

capture multivariate interconnectedness. A potentially fruitful research area would thus be the exploration of time-varying causality in a multivariate analysis, taking volatility clustering into account.

#### Appendix A. Variable Definition

Name	Definition	Variables
Global market conditions		
World market volatility	Conditional volatility of world market return estimated using GARCH (1,1)	VOL_W
Oil price volatility	Conditional volatility of crude oil return estimated using GARCH (1,1)	VOL_oil
Gold price volatility	Conditional volatility of gold return estimated using GARCH (1,1)	VOL_gold
Financial crisis period indicator	Dummy variable to capture crisis periods:	CRISIS dummy
	Period      Start      End	
	1987      01Sep87      01Jan88	
	1997      01Oct97      01Jan98	
	1990      01Oct89      01Nov90	
	2000      01Aug00      01Jan02	
	2007      01Oct07      01Jan10	
(According to Mishkin and White (2003), with recent financial crisis added.)		
Country stock market conditions		
Market development	Stock market value divided by nominal GDP	MD
Dividend yield differential	Dividend yield (DY) = total dividend as percentage of market value for constituents Provides average of individual yields of constituents weighted by market value. DYD = DY of country $i$ – DY of world at given time interval	DYD
Price earnings ratio	Total earnings divided by market capitalization	PER
Stock market volatility	Conditional volatility of stock return estimated using GARCH (1,1)	VOL_C
Market turnover	Total trading value volume divided by total market capitalization	TOV
Country economic conditions		
Inflation	Change of inflation rate $IFL = (CPI_t - CPI_{t-1}) / CPI_{t-1}$	IFL

Interest rate	A country's basic interest rate	IR
Currency reserves	Changes of log (international currency reserves)	CRC
Trade openness	Total trade with world divided by nominal GDP	TOP
Bilateral exchange rate volatility	Conditional volatility of paired exchange rate estimated using GARCH (1,1)	VOL_FX

## Appendix B. A Summary of Determinants of Price Leadership

There are a number of studies focusing empirically on the determinants of stock market co-movement and on the contagion transmission mechanism (see, e.g., Bracker et al., 1999; Forbes and Chinn, 2004; Carrieri et al., 2007; Quinn and Voth, 2008; Baele and Soriano, 2010; Christoffersen, 2012). Bracker et al. (1999) report macroeconomic variables as having significant effects on bilateral lead-lag linkages in explaining long-run co-integration of stock returns. Forbes and Chinn (2004) find that direct trade with large economies (the top five global markets) appears to be the only important factor in explaining cross-sectional market linkages with the large (40) economies; trade competition, bank lending and foreign investment have no significant effect. The above literature provides a general picture of the current state of affairs for the driving forces on market integration.

Carrieri et al. (2007) explore the determinants for market integration using an asset pricing approach. They employed monthly data from January 1977 to December 2000 for eight emerging markets; Argentina, Brazil, Chile, India, Korea, Mexico, Taiwan and Thailand. In their paper, market integration is calculated from systematic risk and a pooled regression was applied to eight emerging markets, but with only four explanatory variables. They find that financial development and market liberalization have a positive impact on market integration, but trade openness and world market volatility do not show any significant impact.

Quinn and Voth (2008) studied four years of data from 120 country pairs, evaluating the relative importance of three contagion channels such as direct trade, the neighborhood effect and financial competition in the banking sector. They conclude that greater openness has been the

single most important cause of growing correlations. Baele et al. (2010) carried out a study consisting of stock and bond returns and a number of economic (fundamental) state variables for the US. Their sample period is from the fourth quarter of 1968 to the fourth quarter of 2007, for a total of 157 observations. They find that macroeconomic fundamentals contribute little in explaining stock and bond return correlation, but other factors such as a liquidity proxy play a more important role. Christoffersen (2012), using a copula correlation approach, reports the transmission mechanisms of different country groups such as developed to developed, emerging to emerging and developed to emerging markets, and finds that the financial market development indicator, term spread, is a significant variable in explaining the co-movement.

Building on the literature, we study stock market shock transmission using three groups of determinants. First, global market conditions are measured by world market volatility, a crisis period indicator for periods of financial crisis identified by large negative price movements (Baur and Schulze, 2005), and gold and oil price volatility as common factors under the globalization hypothesis. Second, country stock market conditions are measured by market development, dividend yield differential, price earnings ratio, stock market volatility and market turnover. Finally, country economy conditions are measured by inflation, interest rate, currency reserve change, trade openness and bilateral exchange rate volatility.

## **1. Global Market Conditions**

The variables considered as measures of world market information or common shocks comprise world market volatility (VOL\_W) and gold and oil price volatility (VOL\_gold and VOL\_oil). To a large extent, these variables serve to indicate global inflation pressure.

### **World Market Volatility (VOL\_W)**

The first variable is commonly applied in the literature on conditional asset pricing (see, e.g., Ferson and Harvey, 1993, 1994, 1998; Bekaert et al., 2002). However, world equity market volatility is a proxy for common shock and it increases equity market co-movement between markets because

of international trade and globalization. World market volatility is introduced as a proxy for the degree of global uncertainty, although Carrieri et al. (2007) find that it has an insignificant impact on market integration in emerging markets. However, Baele (2005) supports evidence of contagion from the US to a number of European equity markets during periods of high world market volatility. In line with these arguments, we expect that world market volatility (common or push factors) is positively related to the causal relationships among markets. This also partially suggests that in a more uncertain market condition the contagious effect between markets is stronger.

Overall volatility across the world's stock markets may influence the level of discount rates commanded around the world. As the variance of a world equity index (VOL\_W) increases, investors around the world may demand higher rates of return to compensate this risk, resulting in higher correlations across different pairs of national equity markets. Erb et al. (1994), Farrell (1997) and Longin and Solnik (1995) all argue that world market volatility is an important determinant of correlations across national markets.

### **Oil and Gold Price Volatility (VOL\_oil, VOL\_gold)**

Oil and gold price volatility are also used as a proxy for the world business cycle. Oil price change is an important variable suggested by Chen et al. (1986). They use it as a measure of economic risk for the US market. Similarly, gold is a commodity, which behaves differently from the movement of the equity and bond markets because investors rebalance their portfolio into different assets during crises and gold is used as a safe haven during these periods.

### **Financial Crisis Period Indicator (CRISIS dummy)**

There is a debate in the international finance literature about co-movement patterns during earlier crisis periods. Contagion represents the increase of co-movement due to the transmission of shocks attributable to the crisis and can be evaluated against interdependence in determining the particular impact of shocks from one market to another during the crisis. For example, while the work of Forbes and Rigobon (2002) and Brière et al. (2012) suggest no contagion, Corsetti et al. (2005) and



Benhmad (2013) find evidence of contagion during crisis periods. In a recent study, Aloui et al. (2011) show that stock market dependence persists both in bull and bear markets, all of which makes the empirical findings inconclusive. Bae et al. (2003) also find mixed results regarding stronger contagion for extreme negative returns than for positive returns. Our empirical method enables us to examine the determinants of time-varying causality. This provides an opportunity to examine how these causality relationships may be different during a financial crisis period. To this end, we need to identify those periods deemed to be a crisis. Mishkin and White (2003) document the complexity of defining and measuring such periods but, using the October 1929 and October 1987 crises as benchmarks, they suggest that a stock market crash should be defined by a 20 percent drop in the market. We follow their definition and identify the 1987, 1990, and 2000 as they have identified in their paper and include the 1997 Asian financial crisis and the latest financial crisis between 2007 and 2010.

## **2. Country Stock Market Conditions**

### **Market Development (MD)**

Market development is one of the most popular information variables applied in conditional asset pricing tests for market integration (see Bekaert et al., 2002; Carrieri et al., 2007). Better developed markets logically attract higher international capital inflows for portfolio investment. Moreover, it is found that stock market development is positively correlated with capital mobility and risk diversification (Levine and Zervos, 1998). Dellas and Hess (2005) find a positive relationship between financial development and stock returns and state that international synchronization is greater the more liquid the stock market. Market development should have a positive impact on stock market integration as it assumes higher economic integration (Carrieri et al., 2007). Christoffersen (2012) finds a positive insignificant relationship between market development indicators and the co-movement of stock markets between emerging–emerging and emerging–

developed countries, but a negative insignificant relationship between developed–developed countries. This might be due to the fact that mature markets become more independent.

### **Dividend Yield Differential (DYD)**

Dividend yield has been an important factor in pricing the international equity risk premium (see Fama and French, 1998), and a popular instrument in international conditional asset pricing models (see Ferson and Harvey, 1993, 1994, 1998; Bekaert and Harvey, 1995). Dividend yield differential (DYD) can be used as a proxy for market performance and earnings. In that case DYD should have a positive effect on co-movement (Longin and Solnik, 1995). We employed the dividend yield differential (the local market relative to the world dividend yield) to gauge how the relative performance of individual markets compared to the world affects equity market integration. We expect a positive relationship between the dividend yield differential and co-movement causality.

### **Price Earnings Ratio (PER)**

This is a proxy for market performance and investor sentiment. Higher PER suggests investors value the companies more optimistically and with higher multiples for a given level of earnings. Positive market sentiment may spill over to another country. Fundamentally, the change of PER in one country may reflect a change in discount rate which may be valuable information that is later reflected in another country. Therefore, a positive impact on the causal relationship is expected. Bekaert et al. (2007) use PER between local and world markets, suggesting the variable as a growth opportunity and showing linkage with market integration.

### **Stock Market Volatility (VOL\_C)**

We include stock market volatility as in modern finance the “volatility feedback” effect has been very popular in explaining movements in stock returns (see Bollerslev et al., 1992). There is also evidence in the international finance literature about co-movement patterns during crises, when volatility increases (King and Wadhwani, 1990; Longin and Solnik, 1995), suggesting a positive

relationship between volatility and stock market co-movement (Corsetti et al., 2005; Benhmad, 2013).

Many argue that stock market volatility is responsible for price declines in a bear market. Individual market volatility is negatively related to market co-movement (Bekaert and Wu, 2000; Whitelaw, 2000; Bae et al., 2003; Wälti, 2011). Shock propagation is more likely in a highly volatile environment overriding all asset classes. Unhedged or leveraged international allocations may also increase contagion. Schinasi and Smith (2001) show that even in an efficient and frictionless setting, spillover effects can emerge on the basis of optimal portfolio decisions taken by leveraged investors as a simple rebalancing response. The hypothesis to test is whether causality of stock market movements is more likely to occur when volatility is pervasively high in all financial markets.

### **Market Turnover (TOV)**

This is a proxy for stock market performance and higher liquidity (Baele et al., 2010). Christoffersen (2012) finds a positive relationship between market turnover and correlation among developed countries. However, they also find a negative but insignificant relationship between emerging markets in the emerging country group. This might be because foreign investors prefer to invest in liquid and healthy markets.

## **3. Country Economic Conditions**

### **Inflation (IFL) & Interest Rate (IR)**

Inflation and interest rates have direct effects on the level of consumption and investment costs, and hence the expected cash flow of listed firms. Boyd et al. (2001) argue that high rates of inflation exacerbate financial market frictions, interfere with the efficiency of the financial system and thus inhibit long-run growth. Similarly, interest rates represent the return on alternative assets to equities and they are the discount rates used in the valuation of stock returns. Thus, higher interest rates may work against stock market integration as they distract capital from equity to bond markets. We

can expect a negative relationship between inflation and stock market causality (Johnson and Soenen, 2002).

### **Currency Reserve Change (CRC)**

One of the indicators for economic stability is changes in international currency reserves. This variable has always been referred to as an indicator of an economy's ability to finance international trade. A large currency reserve accumulation is often associated with easier financing conditions and rapid growth in equity prices as it increases trade (Aizenman and Lee, 2007).

### **Trade Openness (TOP)**

Bekaert and Harvey (1997) point out that trade openness induces correlation between consumption and the business cycle, leading to asset pricing that reflects high risk. Bekaert and Harvey (2000) find that trade openness has a negative impact on dividend yield but a positive effect on GDP growth. As a result they argue that trade openness contributes positively to market integration. If common shocks, which might be associated with changes in demand and/or supply conditions, are more dominant, then this would lead to a higher degree of business cycle co-movement (see, e.g., Frankel and Rose, 1998). Frankel and Rose (1998) find strong evidence that closer trade linkages lead to an increase in the correlation of business cycles. Forbes & Chinn (2004) studied the five largest markets and forty emerging markets and found that direct trade flows are the most important determinants of financial market co-movement. Calderon et al. (2007) find similar evidence for developing countries.

### **Bilateral Exchange Rate Volatility (VOL\_FX)**

Lower exchange rate volatility could lead to enhanced business cycle synchronization, thereby leading to higher stock market co-movement. Bodart and Reding (1999) find evidence that bond and stock market correlations depend negatively on exchange rate variability. Rose and Engel (2002) reach a similar conclusion and show that currency unions bring about higher business cycle synchronization. However, Bordo and Helbling (2004) empirically find the opposite and conclude

that fixing exchange rates does not make any difference to the degree of synchronization of business cycles. The empirical evidence on the relationship between stock market co-movement and exchange rate volatility evidence remains mixed (see, e.g., Johnson and Soenen, 2002; Rose and Engel, 2002).

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**Table 1. Summary of Estimated Parameters**

This table reports the estimation summaries of Equation 1 for the 90 country pairs. Available data on the country MSCI Indexes, denominated in dollars, are collected from Datastream between 1974 and 2012. Panel A reports the parameter summary. Panel B summarizes the transition matrix and Panel C gives the ergodic probability of a country being in the causality regime.

**Panel A. Parameter Summary**

Variable	Mean	Median	N	N significant parameters	N significant & positive causality parameters
$\mu_{i,1}$	-0.149	-0.218	90	80	
$\mu_{i,2}$	0.164	0.130	90	89	
$\psi_i$	0.567	0.474	90	80	76
$\phi_{i,1}$	0.601	0.560	90	88	
$\phi_{i,2}$	-0.165	-0.114	90	81	

**Panel B. Transition Matrix**

State <sub>t</sub>	State <sub>t-1</sub>	
	1	2
1	0.327	0.686
2	0.673	0.314

**Panel C. Ergodic Probability of Causality Regime**

Country	Leading		Country	Lagging	
	Mean	Median		Mean	Median
US	0.34	0.21	BRAZIL	0.39	0.18
GERMANY	0.30	0.06	INDIA	0.35	0.05
FRANCE	0.28	0.07	CHINA	0.19	0.09
CHINA	0.16	0.06	FRANCE	0.16	0.04
RUSSIA	0.15	0.04	UK	0.13	0.06
SOUTH_AFRICA	0.12	0.02	US	0.12	0.02
JAPAN	0.08	0.05	JAPAN	0.10	0.06
UK	0.06	0.05	SOUTH_AFRICA	0.08	0.07
INDIA	0.05	0.06	GERMANY	0.03	0.02
BRAZIL	0.05	0.06	RUSSIA	0.02	0.02
Average	0.16	0.06	Average	0.16	0.06

**Table 2. Descriptive Statistics of the Determinants by Country**

This table reports the summary statistics of the determinants by country. Available data on the country MSCI Indexes, denominated in dollars, are collected from Data Stream between 1974 and 2012. N indicate the number of months in which the data item is available. The abbreviations of variable name are as follows: MD-market development, DYD- dividend yield differential, PER-price earnings ratio, VOL\_C-stock market volatility, TOV-stock market turnover, IFL-inflation, IR-interest rate, CRC-currency reserve change, TOP-trade openness. Detail definitions of the variables are given in Appendix A.

Variables	BRAZIL			CHINA			INDIA			RUSSIA			SOUTH AFRICA		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
<b>Country stock market conditions</b>															
MD	3.04	2.42	160	0.12	0.06	226	2.15	1.70	209	2.06	0.98	172	6.22	5.43	269
DYD	1.21	1.41	214	0.99	0.75	226	-0.78	-0.79	269	-0.51	-0.66	172	1.08	0.85	389
PER	11.66	11.02	156	11.65	10.54	226	19.19	17.81	269	10.08	9.75	172	13.11	13.24	389
VOL_C	0.15	0.09	214	0.23	0.15	226	0.16	0.11	269	0.44	0.22	172	0.09	0.07	389
TOV	5.34	5.11	160	272.04	244.83	226	9.82	7.01	209	169.72	1.48	172	122.84	102.63	269
<b>Country economic conditions</b>															
IFL	0.62	0.51	213	0.33	0.28	225	0.63	0.62	268	1.34	0.84	171	0.77	0.69	388
IR	19.43	17.82	197	2.95	2.63	125	7.45	7.33	233	13.02	7.57	167	11.76	11.00	389
CRC	1.02	1.11	213	2.31	2.11	223	1.67	1.27	268	2.22	2.69	171	1.11	0.84	386
TOP	22.65	23.39	214	52.79	49.41	226	31.35	26.64	269	57.09	55.79	172	52.36	52.05	389
Variables	FRANCE			GERMANY			JAPAN			UK			US		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
<b>Country stock market conditions</b>															
MD	31.50	27.11	287	6.83	1.62	287	8.08	6.21	257	15.10	12.53	307	16.12	9.12	389
DYD	1.05	0.96	389	-0.13	-0.05	389	-1.40	-1.28	389	1.45	1.34	389	0.25	0.11	389
PER	11.68	10.57	226	13.47	13.21	389	39.91	38.16	389	14.56	14.28	389	17.25	17.18	389
VOL_C	0.08	0.05	389	0.07	0.04	389	0.08	0.05	389	0.06	0.04	389	0.07	0.04	389
TOV	2.95	2.48	287	68.98	32.72	209	1.56	0.01	172	37.79	26.77	307	38.09	16.67	389

Country economic conditions															
IFL	0.27	0.23	388	0.16	0.11	256	0.08	0.00	388	0.23	0.27	292	0.28	0.26	388
IR	6.45	5.04	389	3.95	3.50	389	1.87	0.57	311	7.63	6.36	389	5.94	5.57	389
CRC	0.10	0.31	388	−0.04	0.11	388	1.10	0.64	388	0.30	0.21	388	0.61	0.25	388
TOP	48.59	47.93	389	60.51	52.28	389	23.09	21.05	389	54.92	54.39	389	22.89	22.95	389

**Table 3. Determinants of Price Leadership – Leading (Lagging)**

This table reports regression analysis on the determinants of price leadership. The dependent variable is the monthly average of the causality-indicated variable for a given pair-month. It measures the percentage of days in a given month in which the focal country is causing the other country. The country-specific variables are for the focal country in a given pair. In Model 1 (2), we use the characteristics of the leading (lagging) country as explanatory variables. The regressions are estimated with year and country fixed effects to control for unobservable heterogeneity. The sample contains 15,774 pair-month observations. The test row reports a test on the statistical difference between the sum of the emerging and the developed market dummy variables. \*, \*\*, \*\*\* represent 10%, 5% and 1% significance levels, respectively. Detail definitions of the variables are given in Appendix A. The abbreviations of variable name are as follows: VOL\_W- world market volatility, VOL\_oil-oil price change, VOL\_gold-gold price change, MD-market development, DYD-dividend yield differential, PER-price earnings ratio, VOL\_C-stock market volatility, TOV-stock market turnover, IFL-inflation, IR-interest rate, CRC-currency reserve change, TOP-trade openness, VOL-FX-bilateral exchange rate volatility.

Variable	Model 1: Leading			Model 2: Lagging		
	Est.	t-Value		Est.	t-Value	
<b>Global market conditions</b>						
VOL_W	0.456	9.94	***	0.320	6.93	***
VOL_oil	-0.543	-2.53	**	-0.378	-1.77	*
VOL_gold	2.574	0.84		1.829	0.61	
CRISIS dummy	-2.798	-8.73	***	-6.447	-22.15	***
<b>Country stock market conditions</b>						
MD	-0.001	-3.25	***	0.001	4.76	***
DYD	0.018	4.18	***	0.025	5.32	***
PER	0.001	2.57	**	0.002	4.31	***
VOL_C	0.003	0.16		0.085	5.48	***
TOV	0.000	-1.59		0.000	-2.26	**
<b>Country economic conditions</b>						
IFL	0.004	0.86		0.007	1.31	
IR	-0.001	-1.61		0.001	2.01	**
CRC	0.000	-0.14		0.000	-0.32	
TOP	0.001	3.21	***	-0.001	-2.06	**
VOL_FX	0.024	1.84	*	0.029	2.22	**
<b>Country dummies: Emerging markets</b>						
BR	-0.054	-2.77	***	0.330	15.71	***
CN	0.012	0.46		0.191	8.84	***
IN	-0.034	-2.16	**	0.383	20.31	***
RS	0.024	1.03		0.011	0.55	
SA	-0.017	-0.72		0.066	3.30	***
<b>Country dummies: Developed markets</b>						
FR	0.180	6.36	***	0.083	3.75	***
GE	0.186	6.02	***	0.065	2.54	**
JP	-0.009	-0.52		0.092	5.52	***
UK	-0.067	-2.57	**	0.125	5.52	***
US	0.302	16.37	***	0.185	12.44	***
Year effect	Yes			Yes		
Test (Emerging = Developed)	237.29		***	142.95		***
Adj R-Sq	0.365			0.376		
N	15,774			15,774		



## Figure 1. Summary of International Stock Market Leadership

This figure shows a chord diagram of bilateral price leadership among the countries sampled. The connection paths between each country pair are colored according to the dominant country, with developed countries in red and emerging in gray. The bandwidth indicates the relative strength of the connection. Panel A shows the leadership hierarchy of causing, while Panel B shows the lagging hierarchy of being caused. The rankings are obtained from the ergodic probability figures.

### Panel A. Stock Market Leadership – Leading

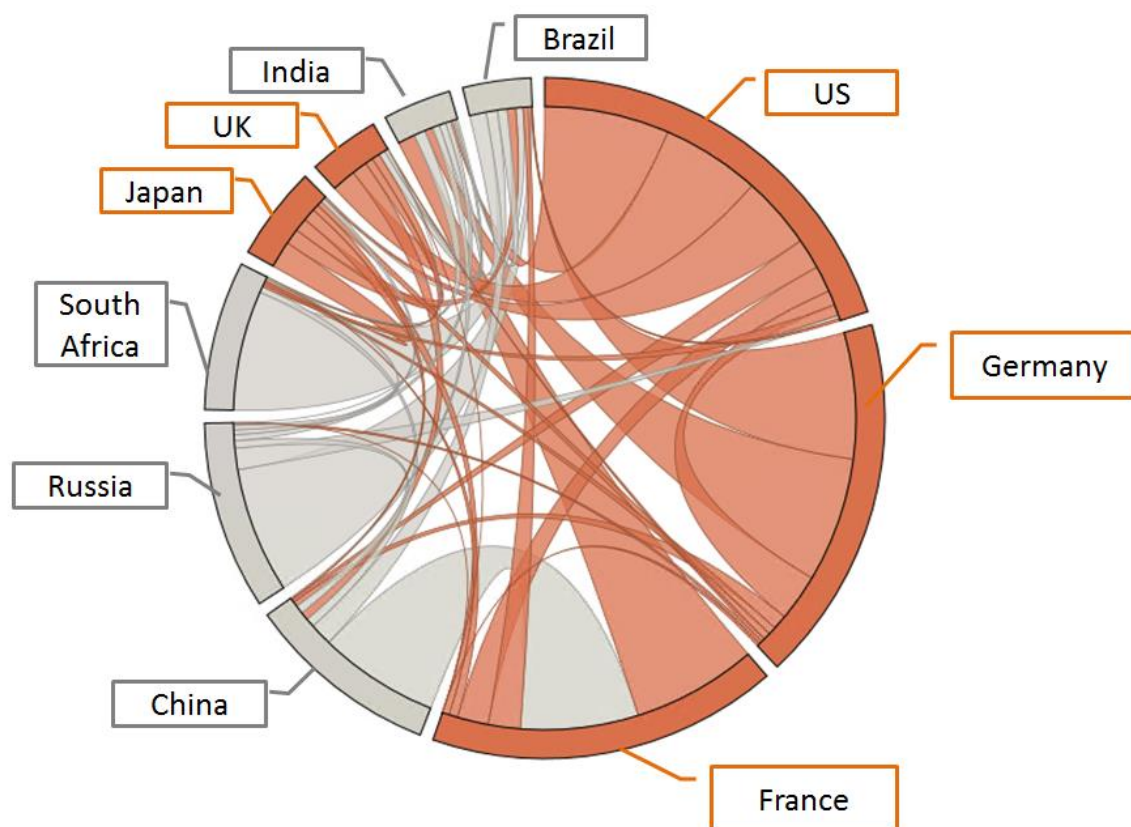
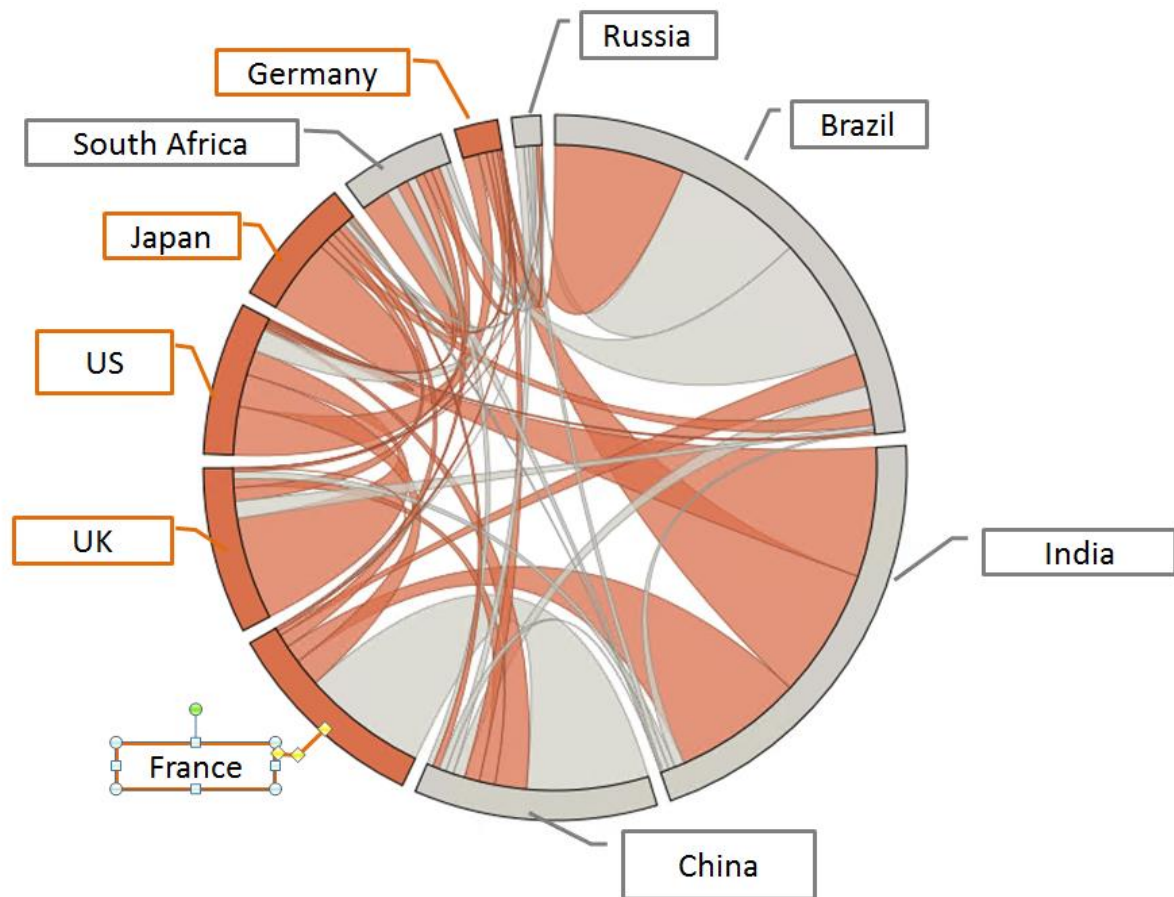


Figure 1 (continued)

Panel B. Stock Market Leadership – Lagging



**Figure 2. Crisis Period Leading Pattern**

This figure shows a chord diagram of bilateral price leadership among the countries sampled during the five financial crisis periods defined in Appendix A. The connection paths between each country pair are colored according to the dominant country, with developed countries in red and emerging in gray. The bandwidth indicates the relative strength of the connection. Panel A shows the leadership hierarchy of causing, while Panel B shows the lagging hierarchy of being caused. The rankings are obtained from the ergodic probability figures.

**Panel A. Stock Market Leadership – Leading**

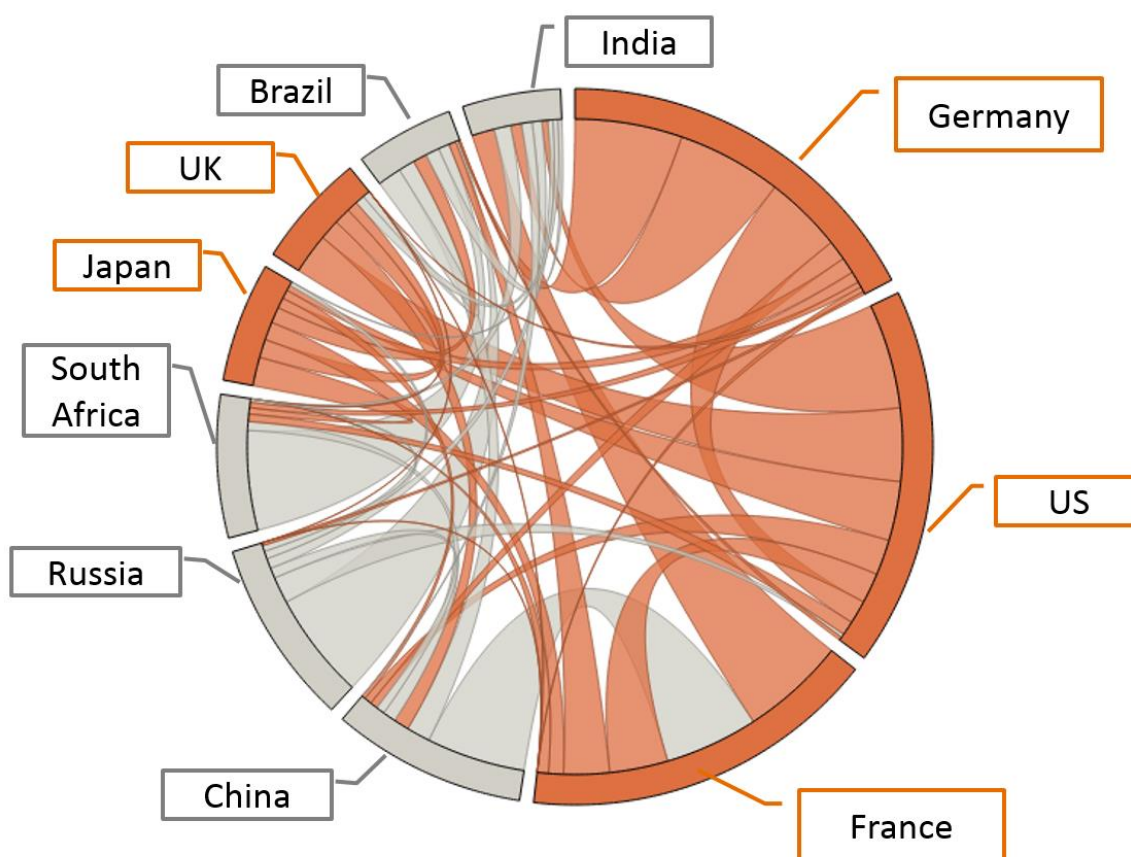


Figure 2 (continued)

Panel B. Stock Market Leadership – Lagging

